Data Recovery

Data recovery in spread spectrum systems is well known. As background, reference is made to section 5.3 of the Dixon text mentioned earlier, and particularly to the discussion of Costas loop demodulators beginning on page 155.

Because the spread spectrum system as provided herein includes multiple correlation channels, data recovery is improved in accordance with one aspect of the invention by extracting data at each channel rather than at only a single correlation channel. It is thereby possible to lower system message error rate and possibly to also reduce the length of or eliminate any required preambles for receiver synchronization.

With reference again to FIG. **19**, it is noted that the correlation pattern **1000** is centered about the primary correlation channel **V1**. The sign of the primary correlation channel **V1** is dependent upon the sign of the data being transmitted. A positive value of **V1** thus corresponds to a logic being transmitted whereas a negative value of the correlation **V1** corresponds to a logic **0** being transmitted.

The correlations at **V2**, **V3**, **V6** and **V7** also have values that correspond to the sign of the data being transmitted. Specifically, the relationship of the voltage outputs at channels **V1**, **V2**, **V3**, **V6** and **V7**, in the absence of noise and distortion, are described as follows:

$$V2 = V3 = R1 \cdot V1 \qquad (7)$$
$$V6 = V7 = R2 \cdot V1$$

where

$$R1 = -2/3$$
$$R2 = 1/3$$

In accordance with the invention, the data sign at the output of each correlation detector, following proper receiver synchronization, is monitored. Depending upon the characteristics of noise and distortion, data may be extracted using only the outputs at channels **V1**, **V2** and **V3**, with an effective signal-to-noise ratio gain of

$$\frac{(1 + 1/L) \cdot \left(\sum_{j=1}^{3} u_j \cdot K_j\right)^2}{(1 + 1/L) \cdot \sum_{j=1}^{3} u_j^2 + 2 \cdot (R1 + 1/L) \cdot u1 \cdot (u2 + u3) + 2 \cdot (R2 + 1/L) \cdot u2 \cdot u3} \qquad (8)$$

where K_j=relative noise free amplitude of V_j with respect to V_1, j=2, 3 (K_j=R1 in the distortion free case), L=the length of the pseudo-random code and u_j=weighting factor for V_j, j=1, 2, 3. The weighting factors are selected according to the particular distortion present.

FIG. **26** is a simplified circuit diagram showing microprocessor **314** responsive to channels **V1**, **V2** and **V3** and programmed to combine all three correlation channel outputs to extract transmission data, with weighting factors selected according to particular distortion known to be present on the transmission medium. Table V illustrates the signal-to-noise enhancements under a few possible distortion and weighting factor scenarios.

TABLE V

WEIGHTING FACTORS FOR Vj			DISTORTION FACTORS FOR Vj			S/N IMPROVEMENT FACTOR
u_1	u_2	u_3	k_1	k_2	k_3	
1	−1	−1	1	−1	−1	1.44
1	−1	−1	1	−0.9	−0.9	1.254
1	−1	−1	1	−0.8	−0.8	1.082
1	−1	−1	1	−0.7	−0.7	0.922
1	−0.34	−0.34	1	−0.67	−0.67	0.971
1	−0.67	−0.67	1	−0.67	−0.67	0.918
1	−0.9	−0.6	1	−0.9	−0.6	1.055
1	−0.8	−0.8	1	−0.8	−0.8	1.09
1	−0.9	−0.9	1	−0.9	−0.9	1.252

An additional advantage of providing a recovery on all channels of the receiver is that random and burst errors, which tend to affect all channels, can be identified and ignored. This is similar to signal presence detection using in-phase and quadrature-phase correlation outputs, as discussed above, but employs all channels rather than orthogonal outputs associated with a single channel.

Furthermore, as an additional advantage of obtaining data recovery at all correlation channels or at least several correlation channels, it is possible to monitor synchronization during message reception. Although synchronization adjustments are not feasible during message reception, the message content may be recovered, without repeats, using the additional receiver channels.

In this disclosure, there is shown and described only the preferred embodiments of the invention; however, it is to be understood that the invention is capable of use in various other combinations and environments and is capable of changes or modifications within the scope of the inventive concept as expressed herein.

What is claimed is:

1. A direct sequence spread spectrum code division multiplex system, comprising:

a timing signal source;

a plurality of transmitters synchronized to the timing signal source and each transmitting data spread by a bipolar pseudo-random code which is a different assigned shift of a common bipolar code sequence; and

a receiver synchronized to said timing signal source for receiving said data signals and discriminating the signal transmitted by a predetermined transmitter spread by a bipolar pseudo-random code having a predetermined assigned code sequence shift from signals transmitted by the other transmitter, the receiver including means for generating a first bipolar pseudo-random code that is a replica of the transmitted common bipolar pseudo-random code and has the predetermined assigned code sequence shift, means for generating a second bipolar pseudo-random code that is a replica of the transmitted common bipolar pseudo-random code and has an unassigned code sequence shift, means for processing said first and second bipolar pseudo-random codes to obtain a trinary code sequence and means